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THE PRESENT-DAY CONCEPTION OF LOGIC.

THE science of logic which is at the present time the center of a very lively and widespread interest has in recent years undergone some very marked and noteworthy developments. These new developments, however, have not proved convincing to many students of the subject because the transition from the older to the newer point of view has not received clear presentation. It is with this in mind that the following brief statement has been formulated. It is an effort to set forth simply a point of view from which this transition becomes an easy and natural one.

In the first place the present-day conception of logic differs from the traditional one in regarding logic as the science of relations instead of as the science of the laws of thought. This transition is readily made if we take thinking as the grasping of relations. One advantage of referring primarily to the relations involved rather than to the act of thinking lies in the 'objective' status thereby imputed to the content of logic. The term 'thinking' has a subjective reference which, in the present interpretation of logic, should not be emphasized. The older view apparently set logic within the field of psychology. From the newer standpoint logic belongs to psychology in no sense other than that in which the natural sciences belong to it. The determination of the connection of relations in general with the individual thinking mind depends upon the solution of the metaphysical problem of the relation of the individual to reality at large. Toward this problem the logician as such assumes an attitude of indifference. The laws of logic hold, whatever the true system of metaphysics may prove to be. And when the logician discusses this question he is for the moment stepping aside from his special task and asserting himself as a human being of broader interests than merely that in logic.

Relations may be regarded as subjective or objective according as the facts they relate are subjective or objective. The laws of relations are valid in either case. The discovery of relations and their connections of course involves experience. But this is true of all science; it is not distinctive of logic. Furthermore, even from the older standpoint the implication of the thinker in the matter received no emphasis after the initial definition. The newer conception is therefore a better formulation of the real character of the subject than the old. This is the justification of its claim to progress.

Another advantage of the new view is that by way of the study of relations there has been effected a contact with a much larger field than that of the older view. The latter dealt preëminently with the implication of one proposition by another. But for certain purposes, *e. g.*, conversion, this was transformed into the relation of membership in a class. This transformation, however, was possible only because these two relations were possessed of certain common features. They were thus made equivalent subspecies of a more comprehensive type. And the fundamental features of this type were the real basis of the operations which were performed upon propositions.

The fundamental features of this type are its transitivity and its asymmetrical character. It is transitive in that if it holds between a first and a second term, and also between this second and a third, then it holds between the first and the third. Its asymmetrical character consists in that though it holds between a first and a second term when taken in one order or direction, it does not at the same time hold between them when taken in the opposite order. The former is readily seen to be the fundamental basis of the syllogism. The latter lies at the basis of the impossibility of converting the universal judgment simply.

As expressed in the older logic, these were laws of the relation of propositions to each other. But propositions are not the only entities which stand in such relations. Nor are implication and the relation of membership in a class the only relations which are possessed of transitivity and asymmetrical character. The older logic was occupied with certain instances of transitive asymmetrical relations, without grasping their essence *per se* and the full sweep of the type. Interesting it is to note, however, that only by depending upon these fundamental aspects could it perform the very operations which were so essential to it. It is the virtue of the newer interpretation that it has appreciated these very fundamental facts. It deals with the entire problem of logic by means of these more general aspects instead of the special features which concerned the older conception. In this way it not only keeps the truth of the old, but places it on a more ultimate and deep foundation. It generalizes the truth of the traditional methods. And this generalization has enabled it to include within its scope situations which could not be dealt with before.

Under the new interpretation the law of the syllogism becomes a law of transitive relations in general. It thus becomes applicable to cases not included under the older treatment of the syllogism. For example, the syllogism dealt with a middle term which had to be a universal and 'distributed.' The general law of transitive relations, however, applies equally well to singular terms. Thus if we begin with the assertion: *A* is to the right of *B*, then by the syllogism we must have some assertion about all objects that are to the right of *B* in order to be able to draw any conclusion. But by the newer formulation of the law, if we know that *B* is to the right of *C*, then we may draw the conclusion: *A* is to the right of *C*; a conclusion which to general experience is of equal significance with the one drawn by the older method. The new conclusion is possible by virtue of the transitive character of the relation of 'being to the right of.' We have drawn a valid and significant conclusion here from individual to individual. Of course if we do know something about all the objects to the right of *B*, and are interested in that class, then there is no objection to drawing a conclusion in accordance with the traditional syllogism. The two cases are simply two different instances of the general law of transitive relations.

It is worth noting that under the older method the transition from subject to predicate is effected by the copula 'is'; under the new it is expressed by the relation 'is to the right of.' The two views of the situation really give two different problems to be dealt with. But the key to each lies in the recognition of the situation as a case of the law of transitive relations. In view of all this we may generalize the law of the syllogism thus: If a term has a transitive relation to a second term, and this second term has the same relation to a third, then the first has this relation to the third. In the application of this law the terms may be either general or singular.

The law is thus stated as a law of relations, not as a law of thought.

The question now arises whether there is any similar law for intransitive relations. There is, although it is more complicated than for the case of the transitive. It is expressed symbolically thus: $(aR_1b), (bR_2c) < (aR_1{*}R_2c)$. That is, if a has an intransitive relation to b, and b has an intransitive relation to c, then the relation of a to c is constituted by the relative product of R_1 and R_2. It may be illustrated as follows: John is the father of William, and William is the father of Henry. But the relation of 'being the father of' is not a transitive relation. It therefore does not hold between John and Henry. The relation of John to Henry is the relative product of the two relations, and has been given the name 'grandfather.'

It is thus apparent that both transitive and intransitive relations can be combined in a similar fashion; but in the case of the former the resulting relation is the same one over again; whereas in the case of the latter it becomes a new relation. The illustrations used have taken the same relation as holding between the first and second and between the second and third terms (whether these relations were transitive or intransitive). We might also consider relative products of different transitive relations or relative products of different intransitive relations, or, finally, relative products of transitive and intransitive relations. The operation in these last three cases would follow the law given above for intransitive relations. It may therefore be regarded as the general formula, the law of transitive relations when repeatedly occurring being a special development for them alone.

The classification of relations as symmetrical or asymmetrical distinguishes between reversible and irreversible relations. But even more important is the relation which is discovered to hold between the two. The process of description in general expresses itself chiefly in asymmetrical relations. The work of science on the other hand is concerned chiefly with equations. The older logic dealt almost exclusively with the former. Consequently this left an apparent hiatus between the processes with which logic and those with which science is concerned. For equality is a symmetrical relation.

Now the point of interest here is that symmetrical relations are resolvable into asymmetrical. Thus if $A = B$, then every A is a B, and every B is an A. But the relation expressed by 'is a' is an asymmetrical relation. Thus a symmetrical relation is equivalent to and replaceable by a pair of asymmetrical relations. This affords us a method of passing from symmetrical to asymmetrical relations at will; and under the proper conditions from the asymmetrical to the symmetrical. It can always be made in the former direction; but in the latter, only when the relation is known to hold in either direction. Thus if it is somehow determined that every A is a B, it must first be determined that every B is an A before we can say that $A = B$.

By means of this connection between the two types of relation the logic of asymmetricals can be shown to apply to symmetricals. And we know at least the conditions under which the transition can be made from the asymmetrical to the symmetrical relation. This shows the relative positions of the traditional logic and scientific formulas to each other. The laws of the asymmetrical relations hold good in both fields; whereas the laws of the symmetricals do not. The appreciation of the connection between the two effects the desired union of the processes of the traditional logic with those of scientific procedure. Thus we now have a logic of both asymmetrical and symmetrical relations,—an achievement of no mean significance to the student of 'thinking' in general.

Another important feature of the new logic is the full acceptance of a law which was suggested by Jevons but never widely adopted. It is the law which Jevons expressed under the two forms of inference—"by added determinants" and "by complex conception." The law of these two forms was not generally accepted because of the difficulty of avoiding ambiguities in using it. Thus we cannot say that if a fly is an animal a large fly is a large animal. But the difficulty here lies not in the incorrectness of the mode of procedure but in the ambiguity of the term 'large.' Being a relative term it changes its meaning as it passes from association with 'fly' to association with 'animal.' However, the difficulty is no greater in this instance than it is in logic in general. Ambiguities always vitiate results. So here, if we avoid ambiguities the result of the operation is acceptable. There is no difficulty, for example, with the inference: if a fly is an animal then an obnoxious fly is an obnoxious animal. The restricting adjective does not change in meaning with the change of substantive. Or, we may say that if a fly is an animal then the head of a fly is the head of an animal. We may even show the law in a still more complex form: a fly is an animal; a head is a part; therefore a head of a fly is a part of an animal.

This mode of reasoning is not uncommon in general discourse. And in scientific and mathematical work its validity must constantly be assumed. Thus when we reason that if a certain amount of fuel will yield a definite amount of heat, then twice this amount of fuel will under the same conditions yield twice as much heat, we are applying the above law. And when in mathematics we say that $A = B$, and $C = D$, therefore $AC = BD$, we are again applying it. To be sure, in both of these illustrations we have used equations, that is—symmetrical relations. But these are only special instances of the law, showing how characteristic the equation is of science and mathematics. In the earlier instances given the relations were asymmetrical: and the equalities involve 'inequalities' in which the same law holds. The law in general may be expressed symbolically thus: $(A < B)(C < D) < (AC < BD)$; or, if A has a certain relation to B, and C has the same relation to D, then the logical product of A and C has this same relation to the logical product of B and D.

This law holds of all relations, transitive or intransitive, symmetrical or asymmetrical. And it may also be regarded as a special case of a still more general law. Not only may there be formed the product of the terms, but also the relative product of two different relations. Thus $(aR_1b)\ (cR_2d) < (acR_1{*}R_2bd)$. Thus: John is the father of Henry; Mary is the mother of William; therefore John and Mary are respectively the parents of Henry and William. Or even better still: John is father of Henry; possessions may be bequeathed by will to children's children; therefore, John's possessions may be bequeathed, by his will as father, to Henry's children. In the conclusion of this inference the term "possessions" is restricted by "John's," the term "children's children" by "Henry," and the relation of "being bequeathed by will" by the relation of "being the father of." The particular phrases used are determined by the exigencies of language.

Thus by a process of successive generalizations, proceeding from the relation of implication among propositions to all asymmetrical transitive relations; then from asymmetrical to all transitive relations; and finally from transitive to all relations whatsoever: we have broadened the scope of the subject to its utmost. We have included not only the law of the syllogism in its generalized form, but also other laws such as that of added determinants.

The movement here suggested runs through the work of Russell and Couturat as they proceed from the logic of propositions to that of classes, then to the logic of relations. Much of Russell's work consists in the development of an exact language along with logic. This is, however, aside from the logic itself. Logic need use no language other than the current one if it choose not to.

Finally, in one other respect the newer logic has developed a feature of significance. The application of the law of added determinants brings out the structure of the term in the conclusion. This leads to a more analytic treatment of the term. In the older logic the term, however complex, was taken as a unit. The operation of the syllogism did not make it necessary to consider the inner structure of the term, so long as it was univocal and in the proper case distributed. But the application of certain of the newly recognized laws, such as Boole's law for the development of a term, makes it necessary that we take the inner structure into account. Thus when we consider two terms, A and B, with reference to each other we must consider the A's that are B's, the A's that are not B's, and the B's that are not A's. Symbolically expressed: $A + B = AB + AB' + A'B$. The detailed study of this structure is necessary for certain phases of the logic of mathematics.

To sum up, without going further into detail: the advance of the newer over the older view of logic consists in the generalization of the field of logic, a generalization easily effected when it is taken as the science of relations; the recognition of certain forms of operation not included in the earlier treatment; and a consideration of the inner structure of the term.

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